THE PHOENIX PROJECT

Coordinated Flight of Multiple Unmanned Vehicles

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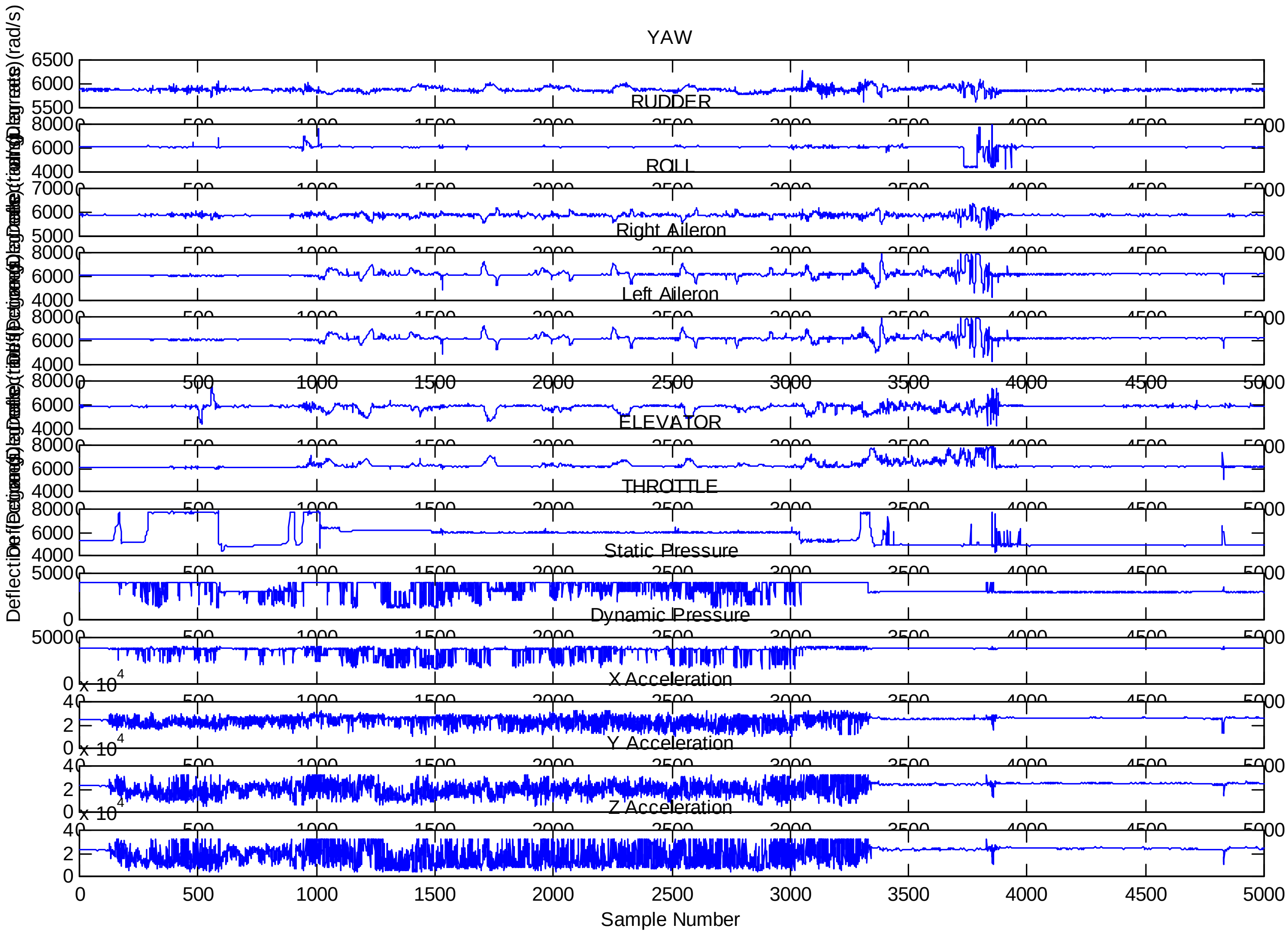
Goals

- Long Term
  - Fleet of 4 Aircraft
  - Way Point Navigation
  - Coordinated Aerobatic Maneuvers
- Short Term
  - Noise Filtration
  - Linear Control for Stabilization
  - System Upgrade

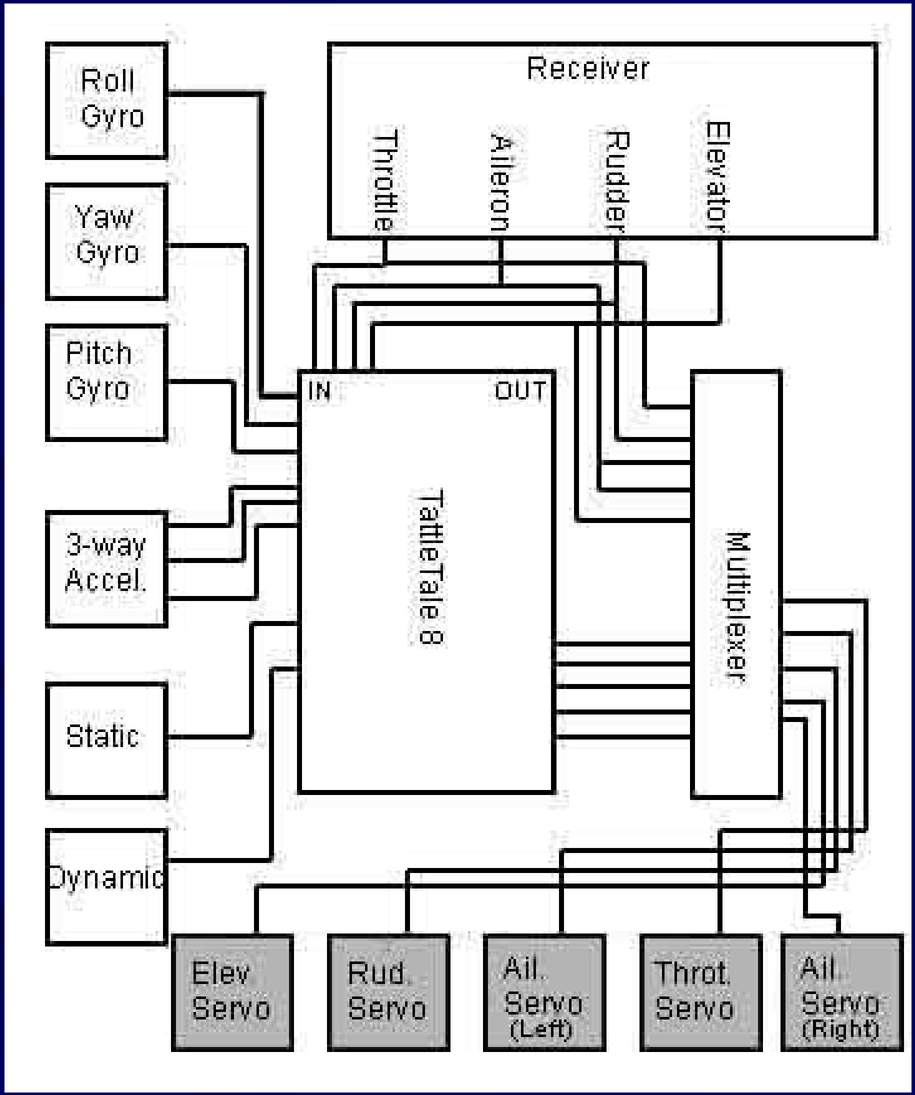
Data- Flight 1



Flight 1- Full Data Set

Data Acquisition System

- Filter Accelerometers
  - Low-Pass filters
- Addition of Daughter Circuits
  - Multiplexer safety switch
  - Comparator Circuit



Full Data Collection System

Low Pass Filter

- Sallem-Key Filter
  - Second Order
  - 6 Hz cutoff
- Currently Testing and Refining

Safety Switch

- Stripped Servo Motor
  - Converts Pulse Width to 1V digital on/off
  - Left Pulse Remnants
    - Eliminated by large time constant RC circuit
- Comparator Circuit
  - Converts output signal to TTL on/off
- Output to Switch Multiplexers

Safety Multiplexer

- Prevents current drain by Tattletale
  - Allows user control during Tattletale failure
- Controls Input Data to the Tattletale
  - Allows Data Collection during user control
  - Prevents Data Collection during Tattletale control
- Powered by Tattletale
  - Automatic Failure Control

Safety & Switch Multiplexer System

- Differing Power Sources Allow for 3 States
  - State 1: User Control with Tattletale Power
    - Safety Muliplexer: Allows Tattletale Data Collection
    - Switch Multiplexer: Allows User Control
  - State 2: Tattletale Control
    - Safety Muliplexer: Prevents Tattletale Data Collection
    - Switch Multiplexer: Allows Tattletale Control
  - State 3: Tattletale Failure
    - Safety Muliplexer: Prevents Tattletale Data Collection
    - Switch Multiplexer: Allows User Control

State Space System

$$\boxed{\vec{x}_{n+1} = Ax_n + B\vec{u}_n}$$

$$\boxed{\vec{y}_n = C\vec{x}_n + D\vec{u}_n}$$

De-coupled System

$$\dot{\vec{x}}_{long_{n+1}} = A_{long}\vec{x}_{long_n} + B_{long}\vec{u}_{long_n}$$

$$\vec{x}_{long} = \begin{bmatrix} u \\ w \\ q \\ \theta \end{bmatrix}$$

$$\vec{u}_{long} = \begin{bmatrix} \delta_e \\ \delta_{th} \end{bmatrix}$$

$$\dot{\vec{x}}_{lat_{n+1}} = A_{lat}\vec{x}_{lat_n} + B_{lat}\vec{u}_{lat_n}$$

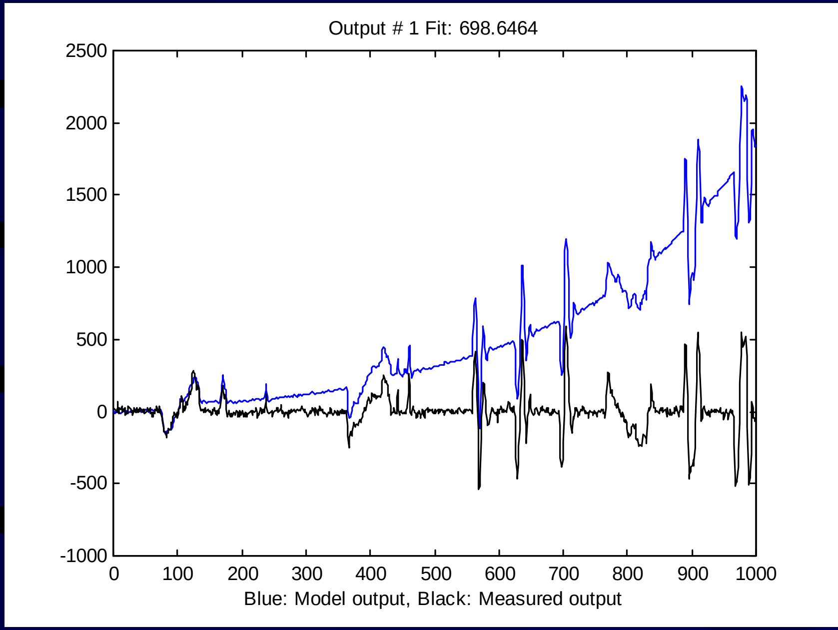
$$\vec{x}_{lat} = \begin{bmatrix} v \\ r \\ p \\ \Phi \end{bmatrix}$$

$$\vec{u}_{lat} = \begin{bmatrix} \delta_a \\ \delta_r \end{bmatrix}$$

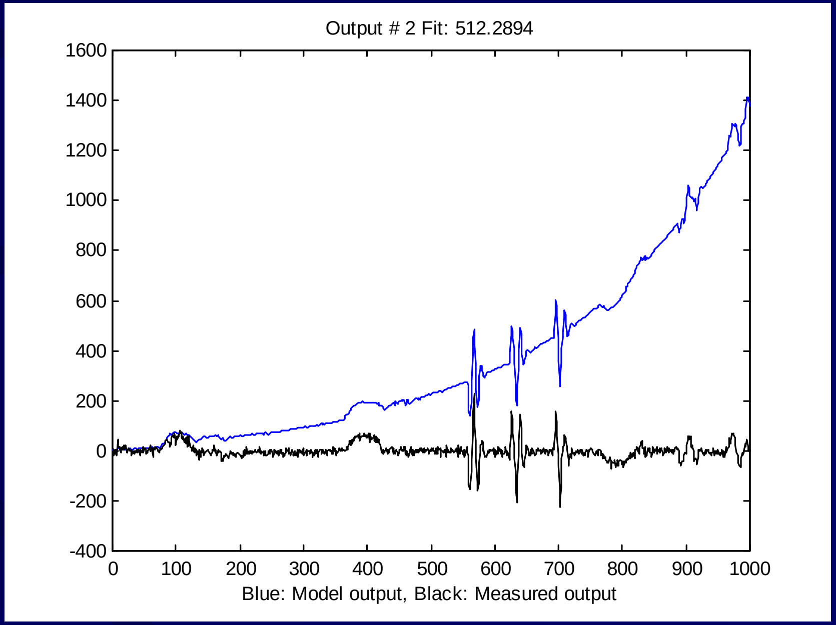
MATLAB Analysis

- Lateral Model based on Flight 3
  - First 4 eigenvalues most important
    - λ > 1 implies stable
      - Dutch Roll Mode
        - » 0.6625+0.4346i
        - » 0.6625-0.4346i
      - Roll Mode
        - » 0.2200
      - Spiral Mode
        - » 0.9989
  - Fifth and Sixth eigenvalues eliminate drift
    - » 0.8144+0.1174i
    - » 0.8144-0.1174i

4th Order Model

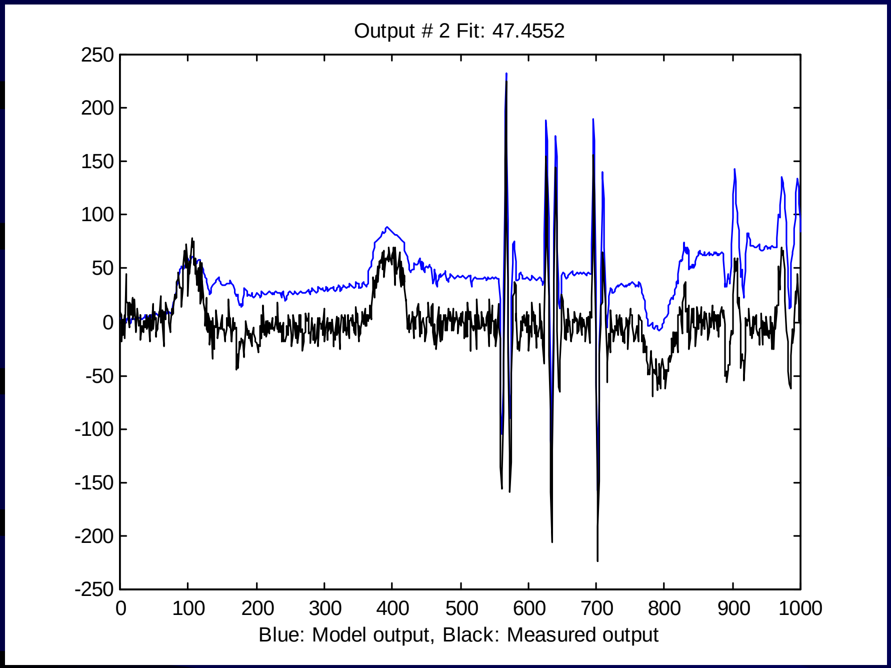


•4th Order Yaw Model

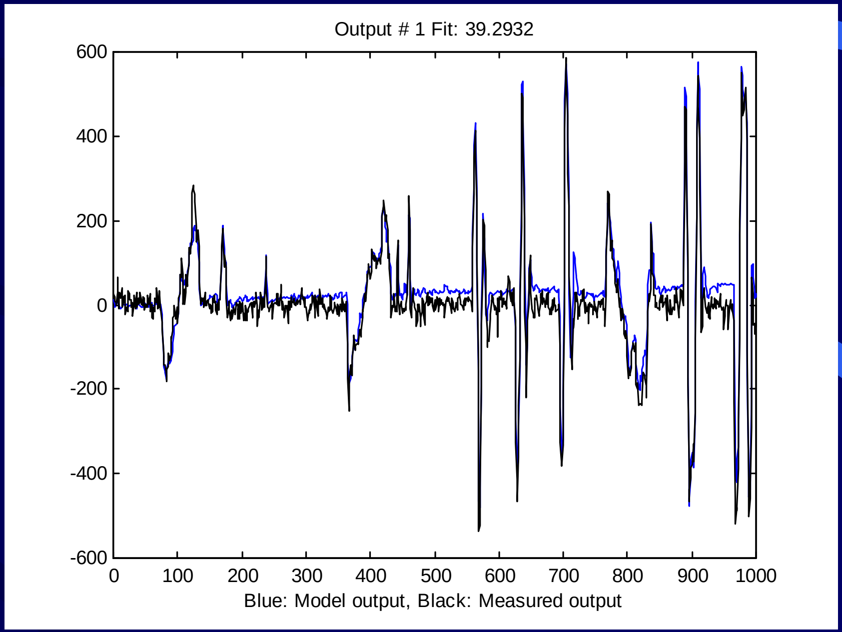


•4th Order Roll Model

6th Order Roll Comparison

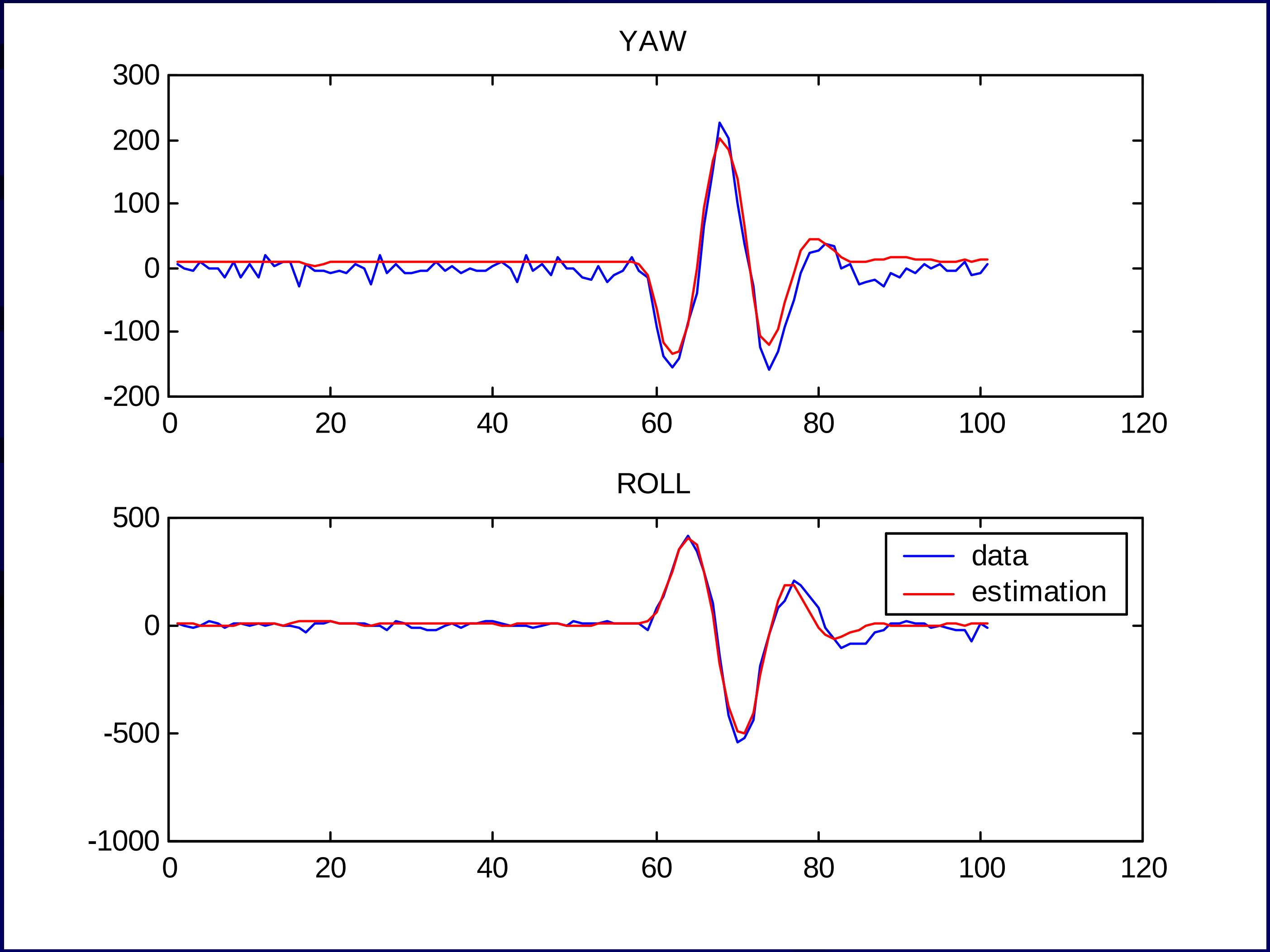


•First 1000/6000 Samples



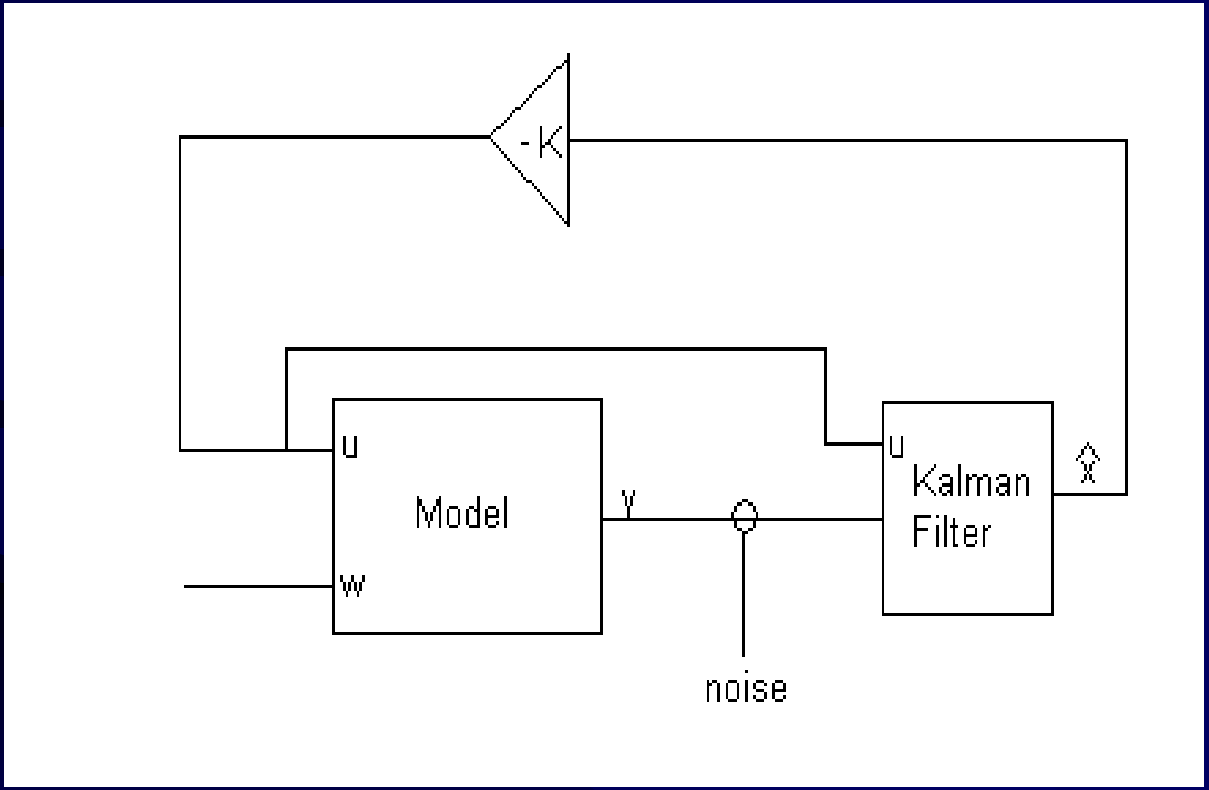
•Roll: First 1000/6000 Samples

Flight 3 Post-Kalman Filter Comparison



•Result of MATLAB simulation for samples 500-600 of Flight 3

Control System



GPS

- Pharos iGPS 180 Receiver
  - Laptop version
  - Interface with Tattletale through serial connection
  - 2.2” x 1.9” x .8”
  - 2.4 oz.
  - Sample Rate of 1 Hz
    - Used to eliminate drift from integration of accelerometers
  - 5 meter reported accuracy
  - NMEA-0183 Protocol
  - Water Resistant

The Need for a System Upgrade

- TattleTale:
  - Lacks Memory
  - Lacks Processing Power
  - No Wireless-LAN Capability
- Upgrade Options
  - Pentium Half-Board
  - Compaq iPAQ
  - Casio Cassiopeia

Compaq I-PAQ

Advantages:

- Small and lightweight
- Intel StrongArm (206 mhz)
- PCMCIA Wireless LAN

Disadvantages:

- Not Durable
- Extra Bells and Whistles we don't need
- Expensive and Out of Stock

Casio Cassiopeia

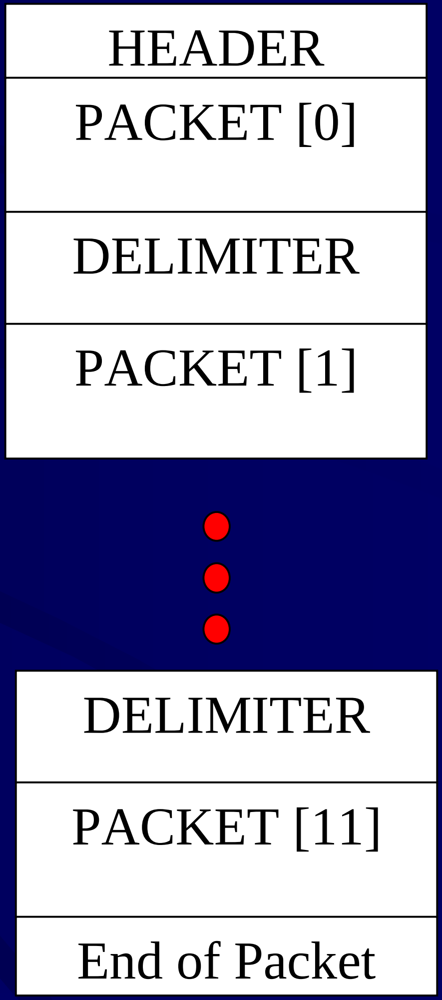
- Advantages:
  - Durable
  - MIPS Processor (150 mhz)
  - Compact Flash Card
- Disadvantages:
  - Larger than an iPAQ
  - No Expansion pack

TattleTale to Processor Communications:

- TattleTale:
  - TPU Channel
  - High speed serial communications
  - Done every time we collect data
- Main Processor
  - Communicates over "COM1"
  - Read thread waits for serial Data
  - Write method sends byte array to TattleTale

Protocol for TattleTale to Processor Communications

- Logged Data sent over as array of bytes
- Data sent over in hex
- Data read in as chars, converted to integers
- Each array has a header
- Each element has a delimiter between it



Wireless LAN Communications:

- ORiNOCO PCMCIA card from Lucent
  - 1750 feet 1 Megabit / second
  - Low Power
  - Windows CE Driver
  - Use Compact Flash card adapter from Accurite

Wireless LAN Configuration

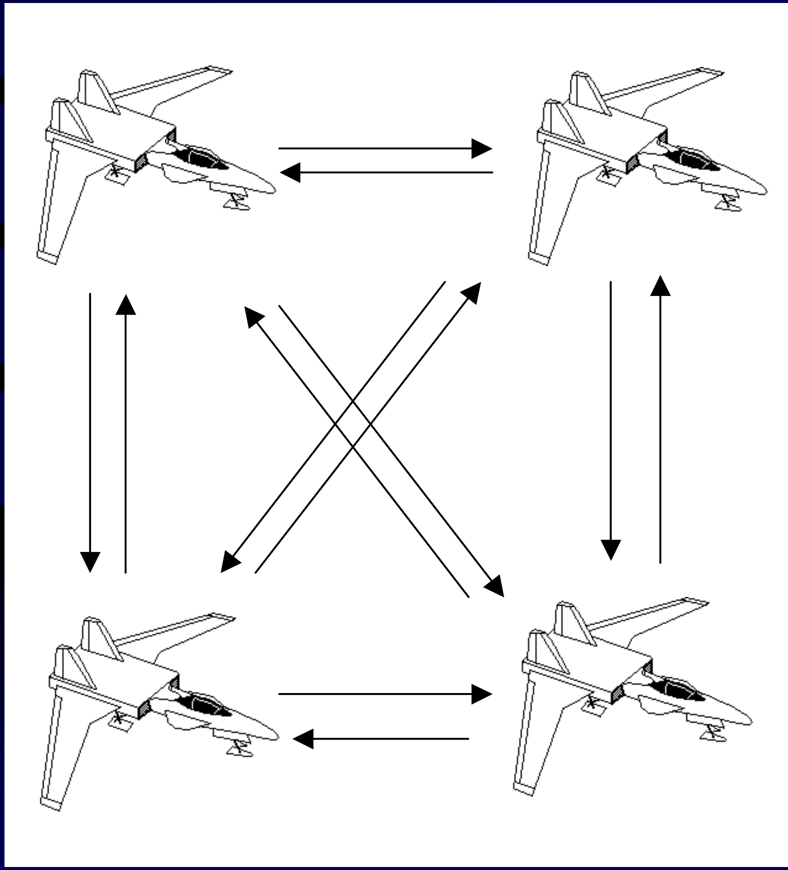
- Works w/ 4 computers in a wired cluster
  - Each Air Plane has its own IP Address
- Tested w/ 2 computers in peer-to-peer wireless network
- Use Java as Programming Language
  - built in libraries
  - portable (Personal Java)

Wireless LAN Features:

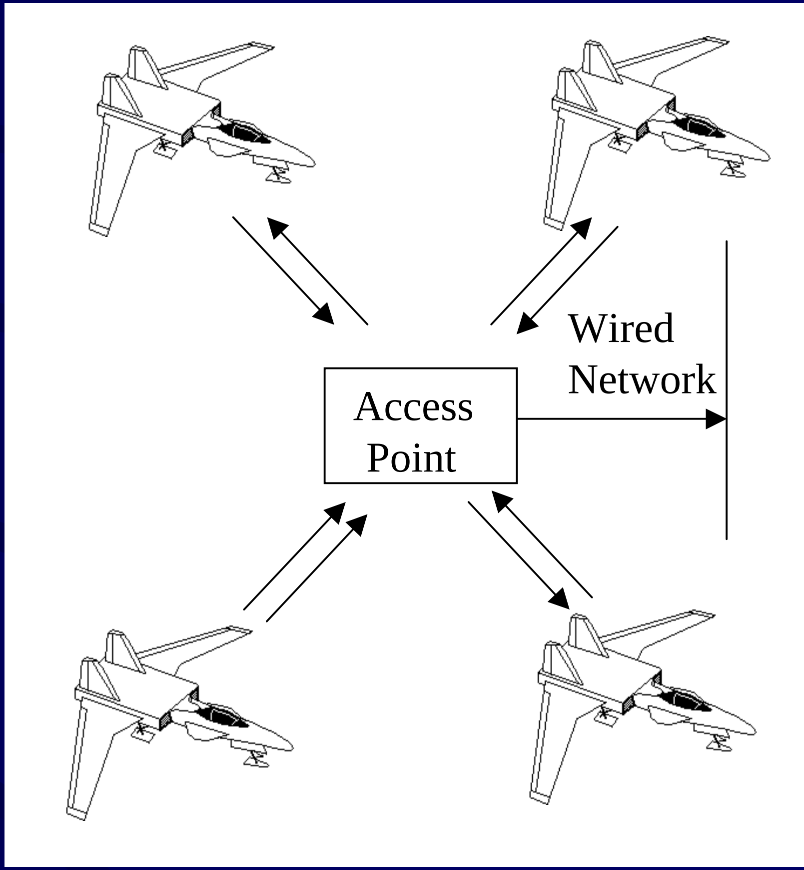
- Messages customizable via Java object serialization
- Plane-to-plane communication automatically re-established if plane goes out of range
- TCP/IP Sockets Provide:
  - Resends Lost Messages
  - Error Checking

LAN Configurations

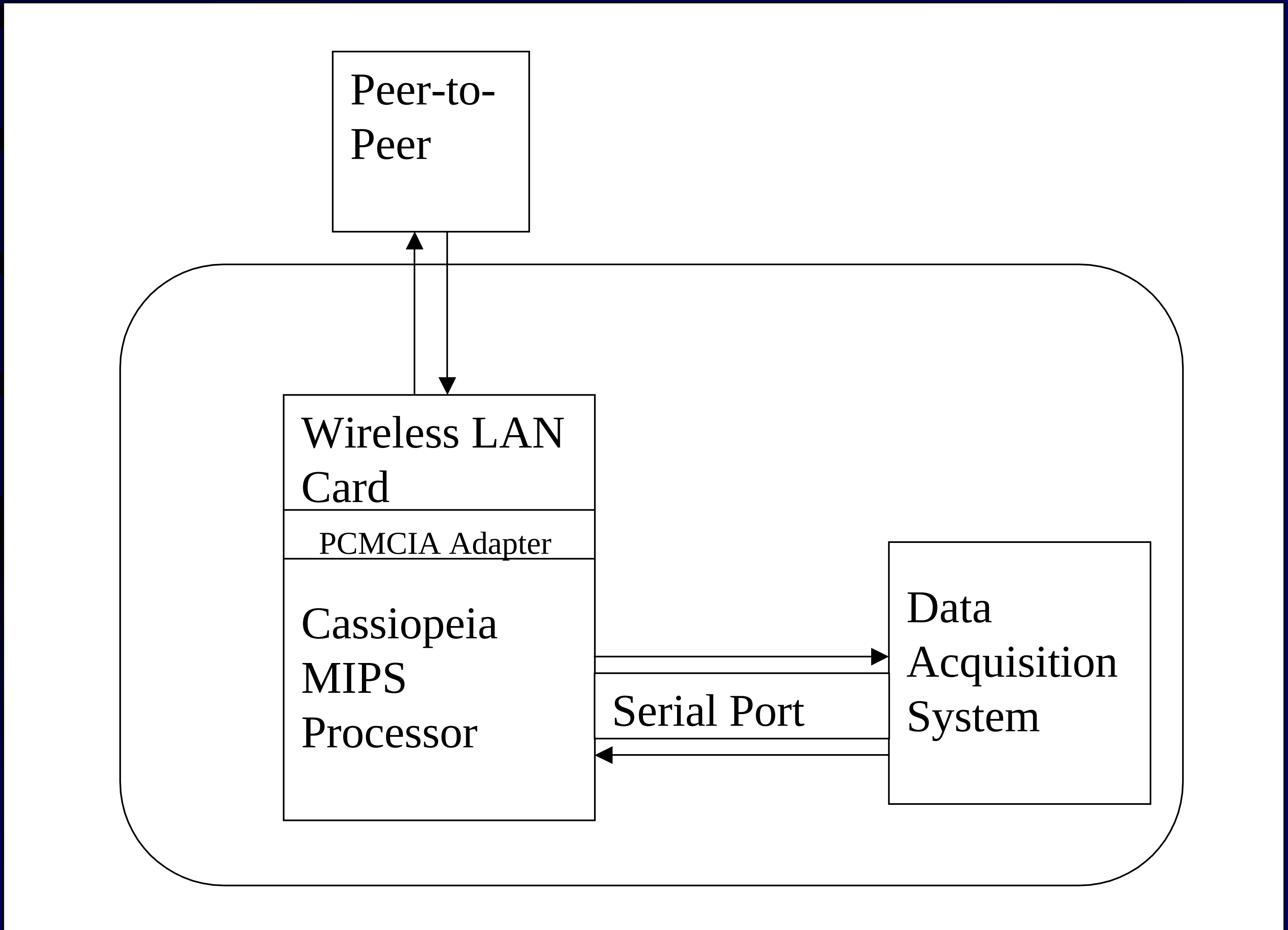
Peer-to-Peer



Network with a Hub



Overall Design of System



What’s Next?

•Linear Control

•Tattletale to Cassiopeia serial Communication

•Integration of GPS System

•Way Point Navigation Control

•Integration of Wireless LAN System

Special Thanks

- Professor Stengel: for allowing our involvement in this project
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